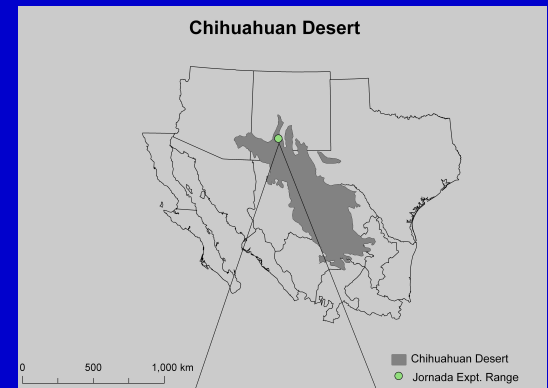# Long term vegetation change at the Jornada: importance of spatial processes and landscape context

Debra Peters
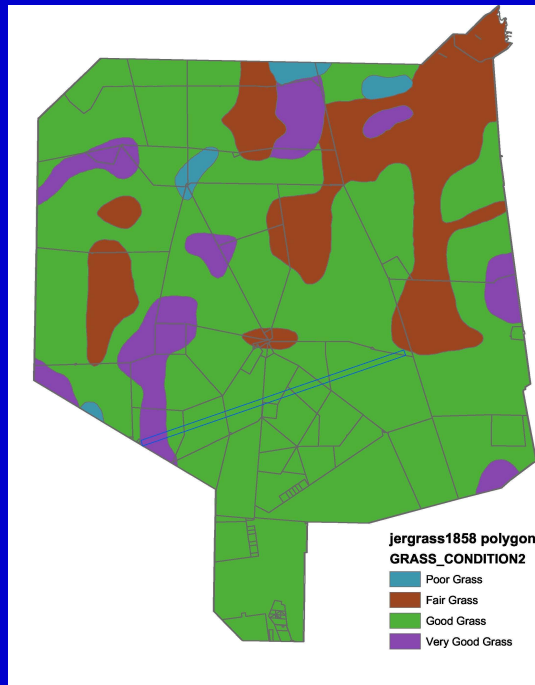
Kris Havstad, Jin Yao, and Bob Gibbens

USDA ARS, Jornada Experimental Range
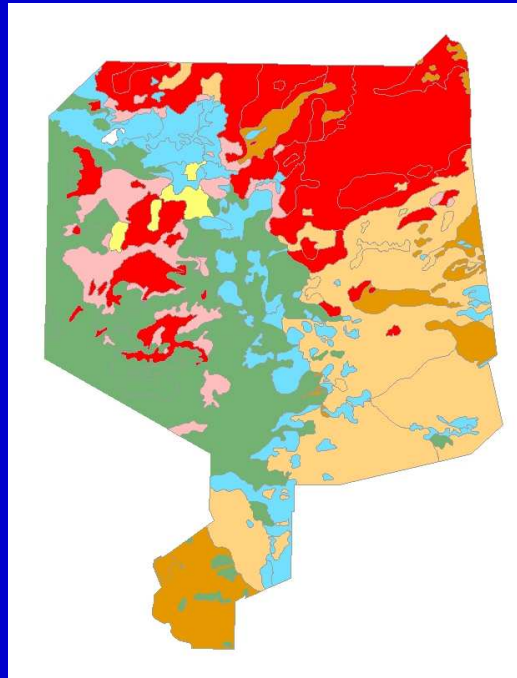Jornada Basin Long Term Ecological Research site

Chihuahuan Desert

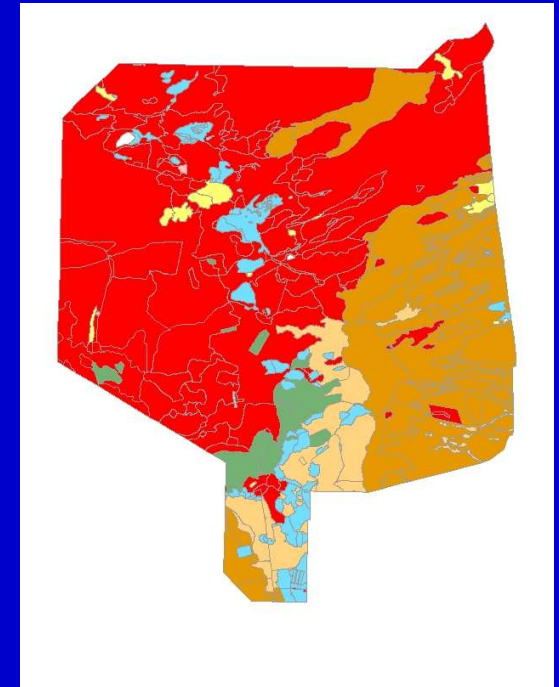Jornada Basin ARS-LTER site: broad scale shift in dominance

1858 — Grasslands

1915 — grass 37%, shrub 63%

1998 — grass 8%, shrub 92%

Legend:
- Bare
- Creosotebush
- Mesquite
- Other Shrubs
- Playa Grasses
- Snakeweed
- Tarbush
- Upland Grasses

jergrass1858 polygon GRASS_CONDITION2:
- Poor Grass
- Fair Grass
- Good Grass
- Very Good Grass

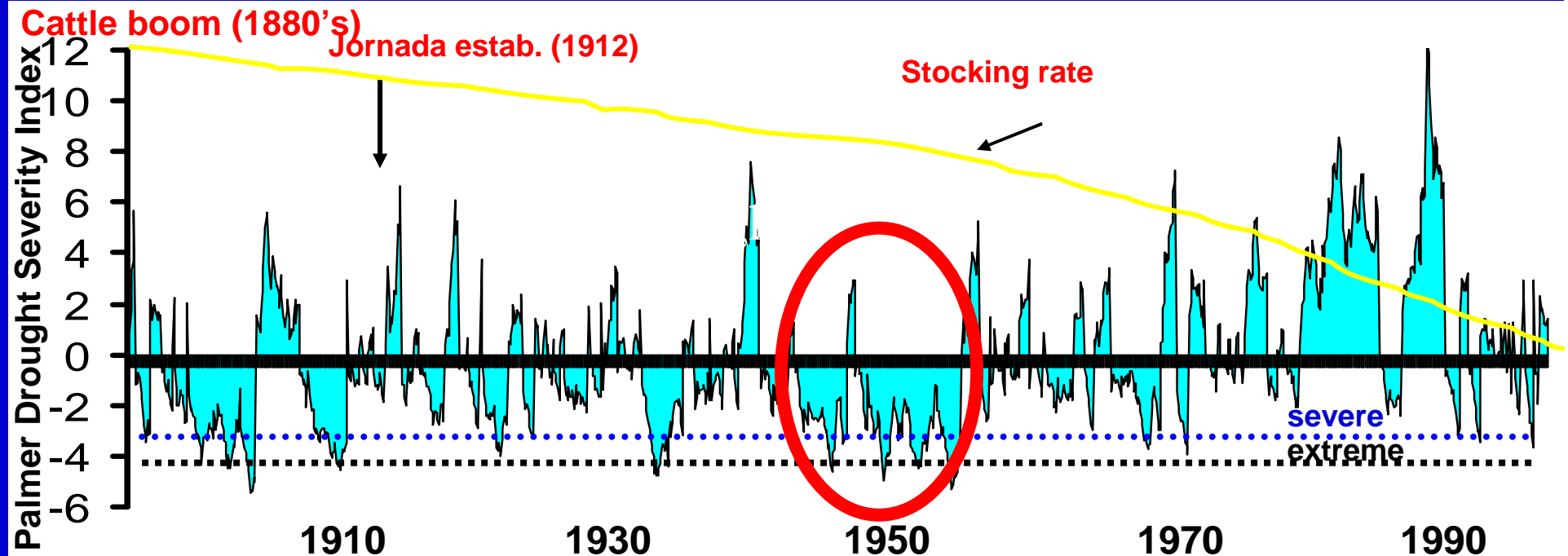Gibbens et al. 2005. JAE

Perennial grasslands → Shrublands

Future –

Shrublands → ??????????

Possible explanations for grassland to shrubland conversion
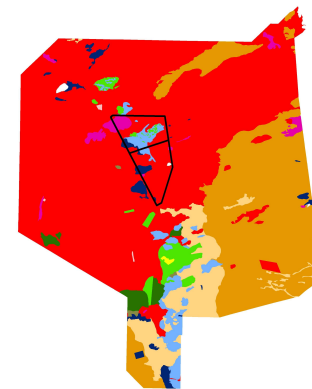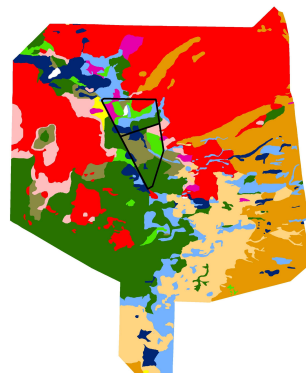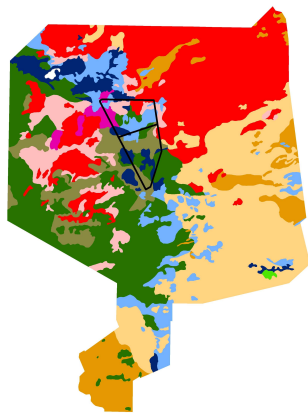
Extreme drought of the 1950s

These broad scale drivers are insufficient to explain spatial variation in vegetation dynamics.

1915   **1928-29**   **1998**

Legend:
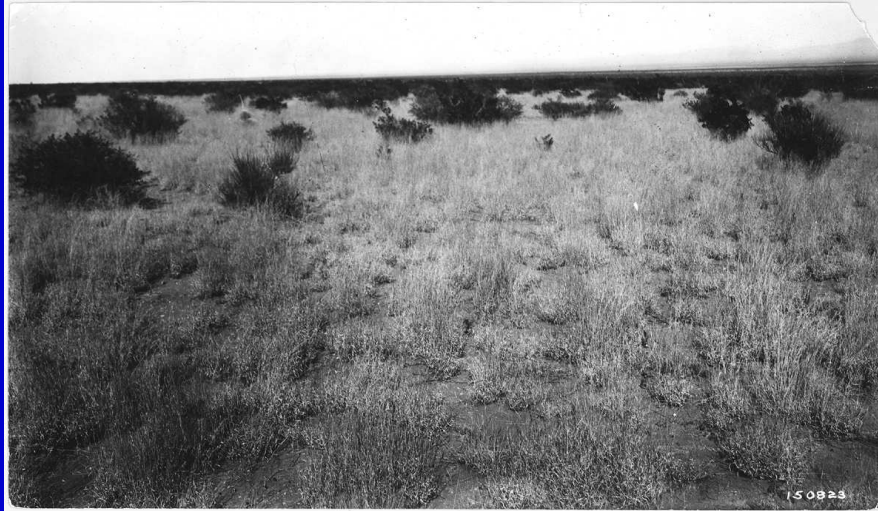- Bare
- Aristida spp
- Black grama
- Burrograss
- Sporobolus spp
- Tobosa
- Other grasses
- Broom snakeweed
- Creosotebush
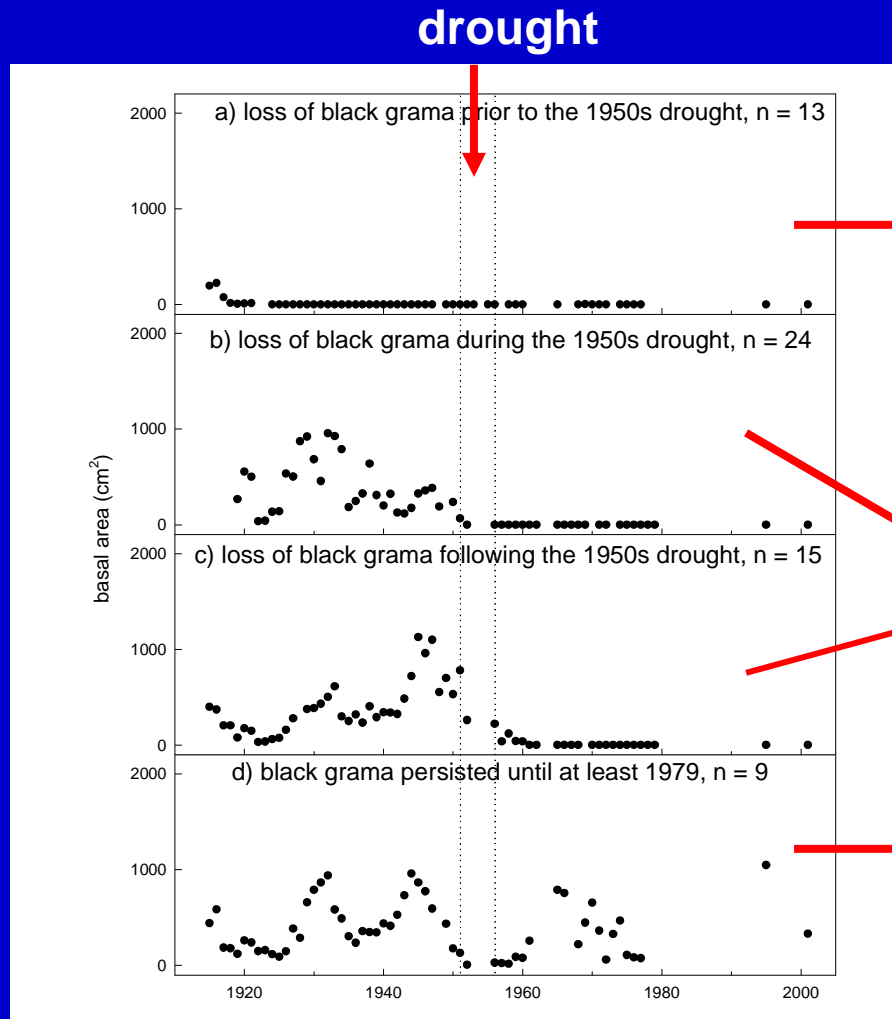- Mesquite
- Tarbush
- Other shrubs

April (1920)

July (2001)

Jornada exclosure (estab. 1915) on a lower bajada

Grazing or its exclusion is not always sufficient to explain shrub invasion dynamics

DROUGHT IS OFTEN INSUFFICIENT TO EXPLAIN VARIATION IN GRASS PERSISTENCE

drought

a) loss of black grama prior to the 1950s drought, n = 13

b) loss of black grama during the 1950s drought, n = 24

c) loss of black grama following the 1950s drought, n = 15

d) black grama persisted until at least 1979, n = 9
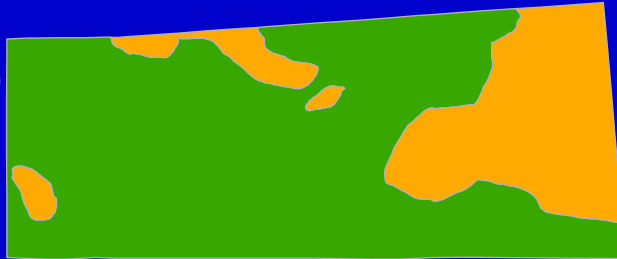
basal area (cm^2)

Perennial grasses lost before the drought

Perennial grasses lost during and shortly after the drought
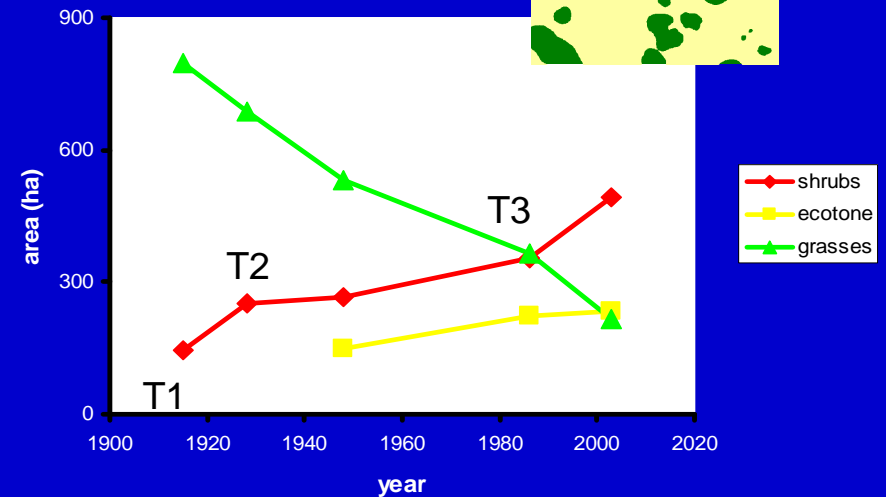
Perennial grasses remain to present
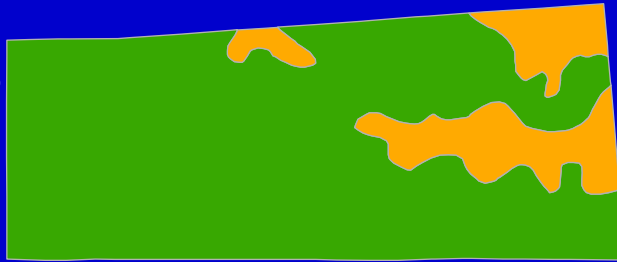
Yao et al. Landscape Ecology (submitted)
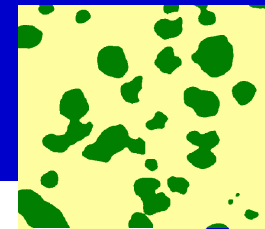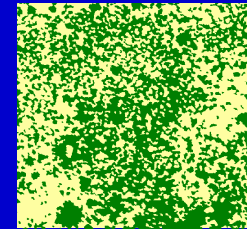
**Broad scale drivers are insufficient to explain temporal variation in vegetation dynamics**

Peters et al. PNAS (2004)

Key properties of arid and semiarid systems that lead to spatial and temporal variation in grassland-shrubland dynamics:

a. Historical legacies (climate, geomorphology, disturbances)

b. Environmental drivers (climate, disturbance regime)

c. Dynamic template of patterns in ecological variables, including spatial context

d. Multiple transport vectors (horizontal, vertical)

e. Redistribution of resources within and among spatial units

Interactions and feedbacks within and among scales generate threshold behavior, nonlinear dynamics, and the potential for multiple future states

Hierarchy of interacting spatial and temporal scales

"Cross scale interactions"

1 m

3 m
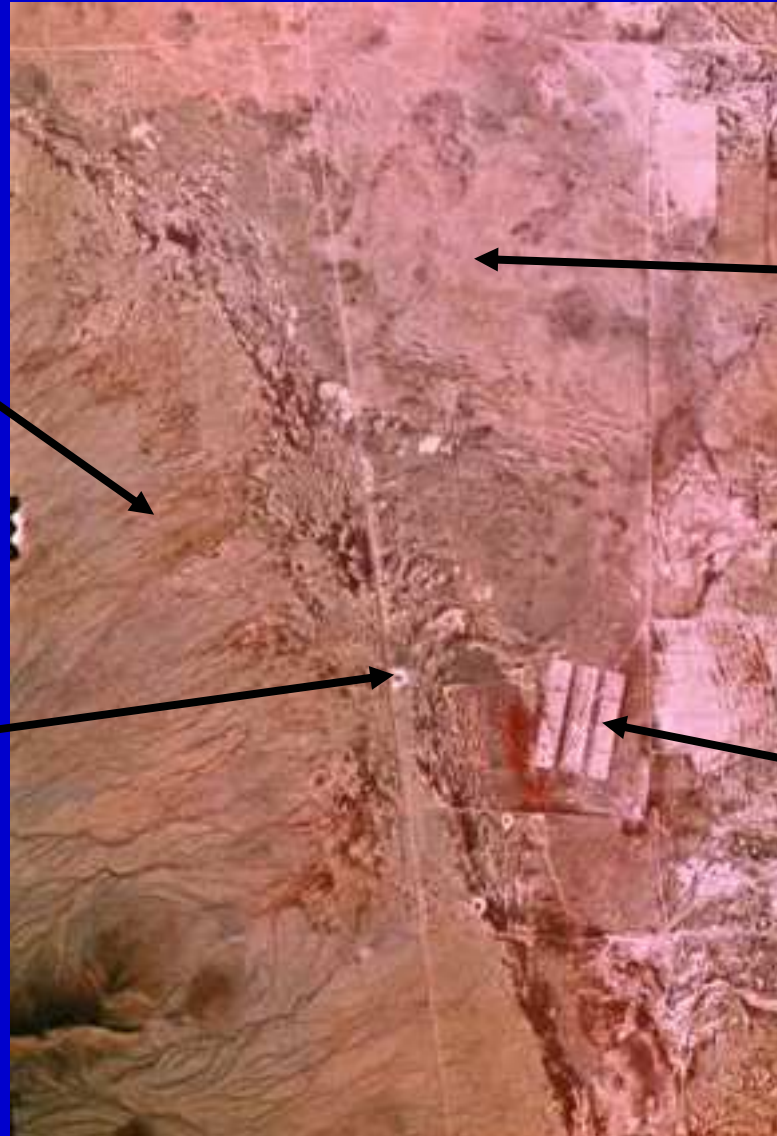
PLANT-INTERSPACE

PATCH-INTERPATCH

GRASSLAND LANDSCAPE UNIT

SHRUBLAND LANDSCAPE UNIT
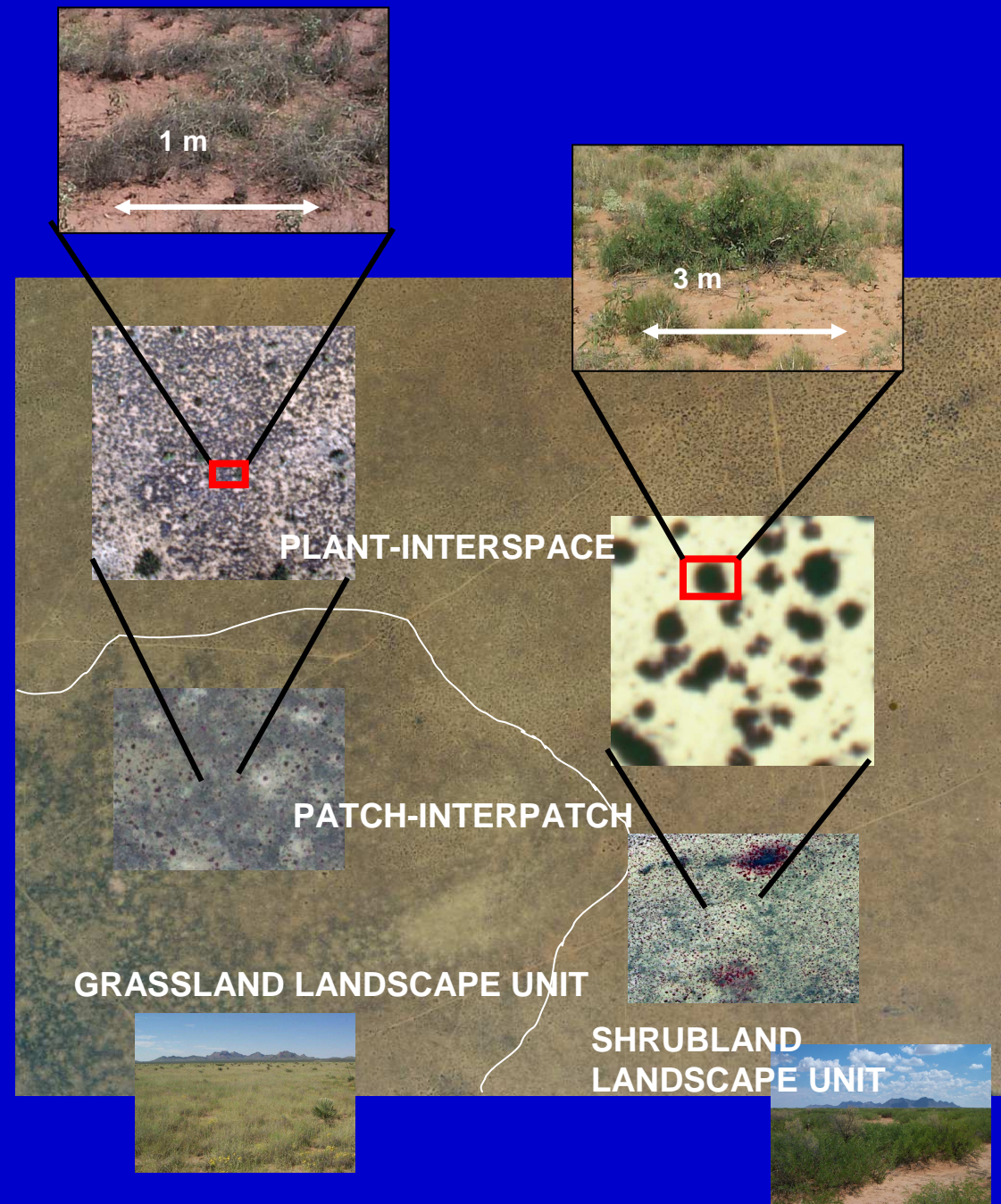
Drivers interact with dynamic template and transport vectors to redistribute resources across scales

WATER

WIND

ANIMALS

HUMAN ACTIVITY

Feedbacks from resource redistribution to the dynamic template and transport vectors generate nonlinear dynamics and threshold behavior
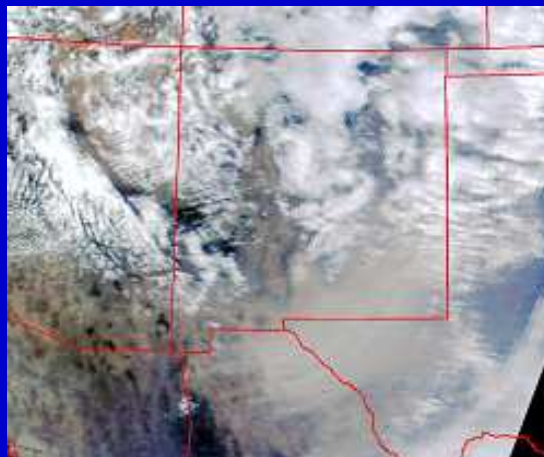
Plant scale

Soil translocation via ant nests affect plant water availability

Patch scale

"beads" collect water and increase plant biomass

Regional scale

soil erosion by wind from desertified areas results in soil deposition downwind

Landscape unit scale

Human activities influence cattle movement with increase in mesquite dispersal

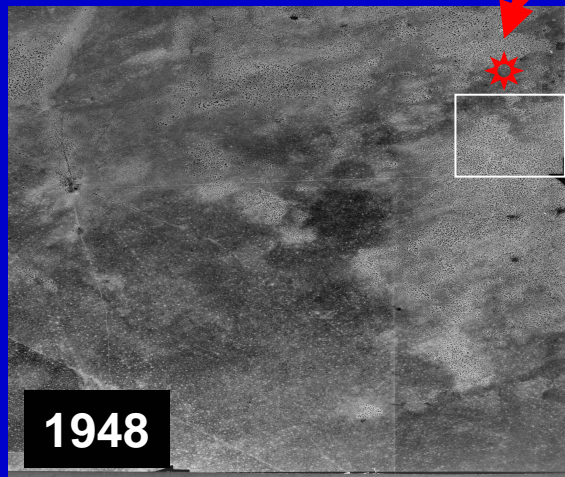Dikes increase plant water availability

Historical legacies
interactions among drivers,
spatial context, and
transport vectors (humans)

Possible camp of Jornada
Mogollon (ca. 1100-1400 AD)

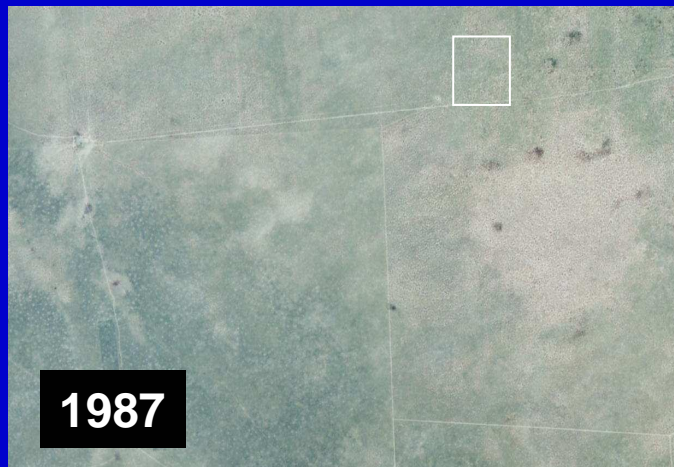Cattle concentrate mesquite
seeds along roads (Camino Real)

1858

veg1858g
- 1- grass
- 2- tarbush
- 3- mesquite
- 4- yucca
- 6- no shrub
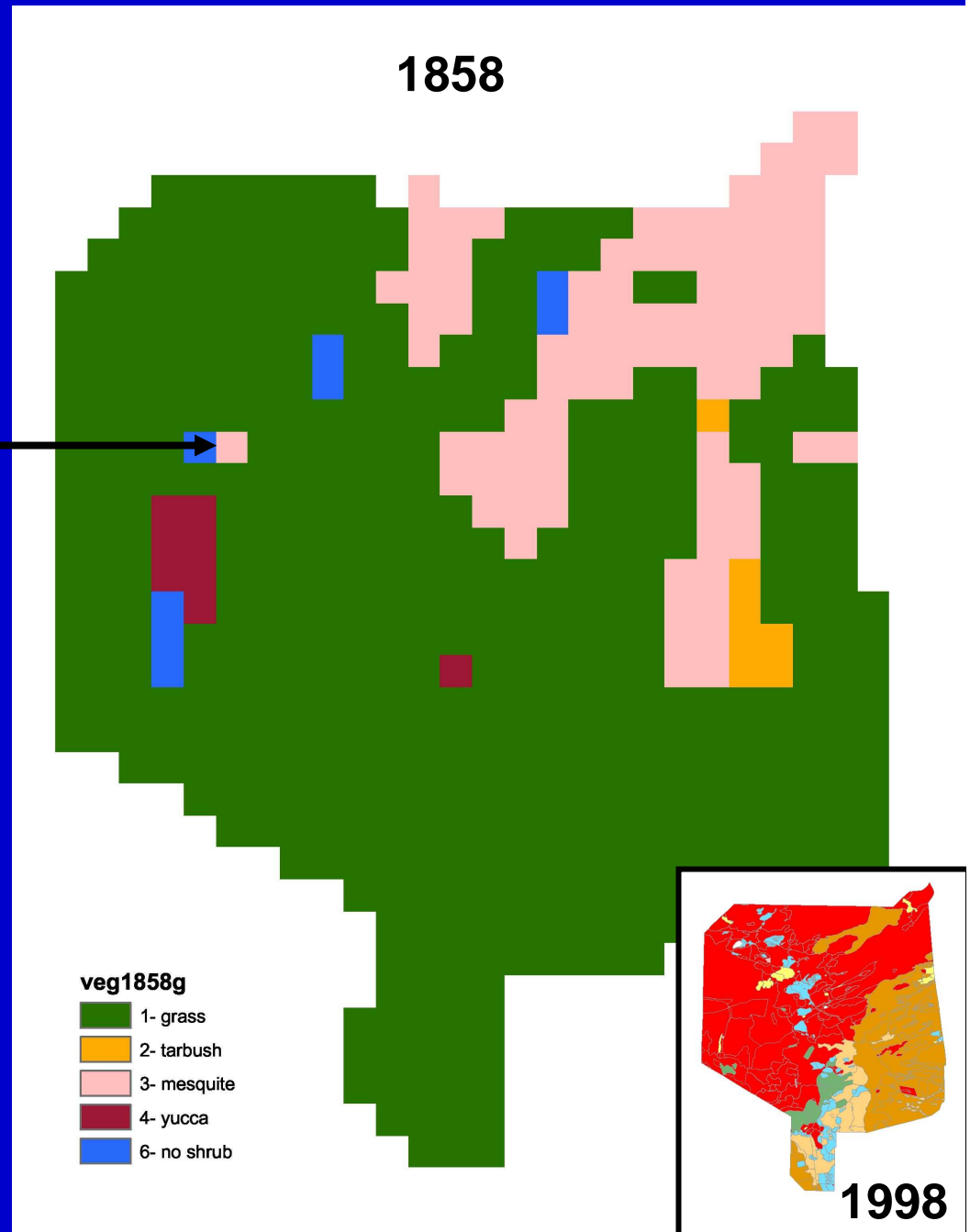
1998

More recently ….

"natural revegetation" exclosure constructed
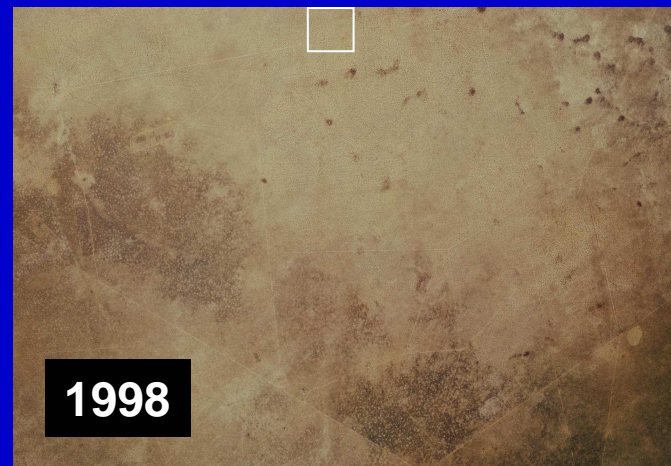
1933

1948

Location of exclosure near dunefield resulted in shrub dominance even with protection from cattle

2001

1987

1998

Peters et al. (submitted)

Even more recently (2002) -
Interactions among drivers, dynamic template, and transport vectors (cattle, water)
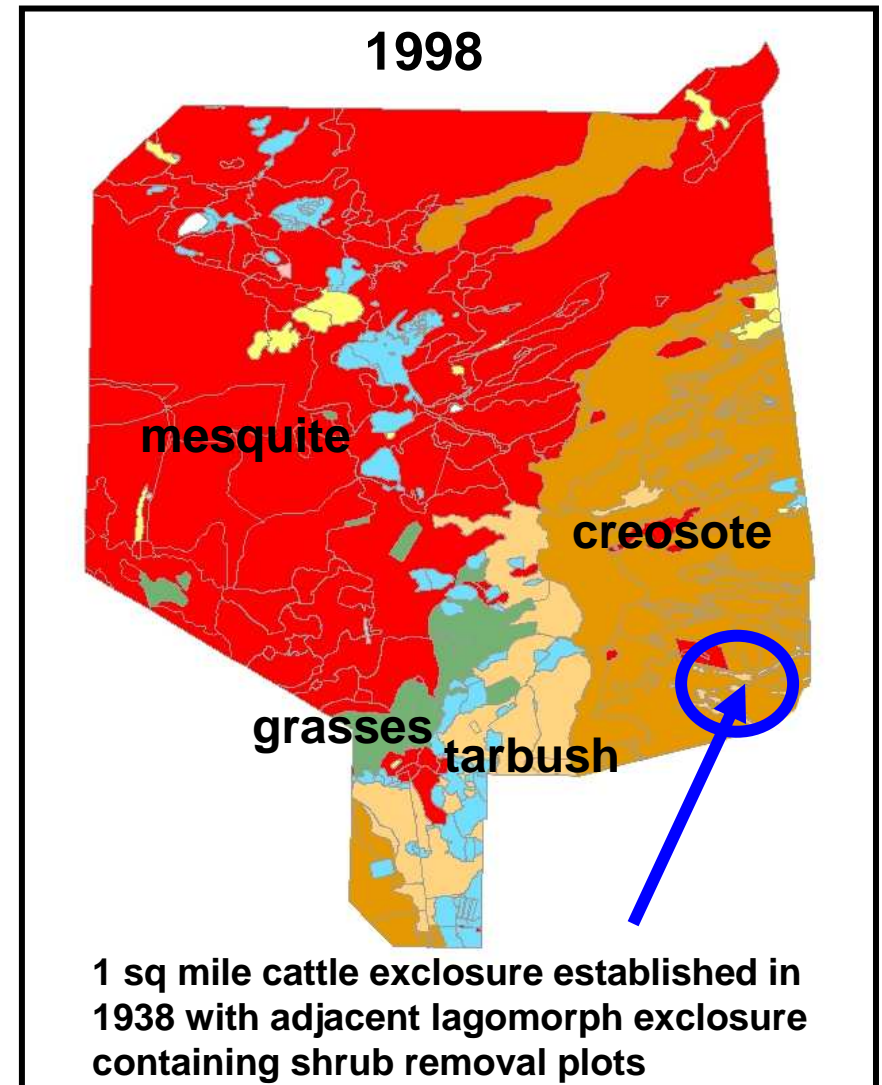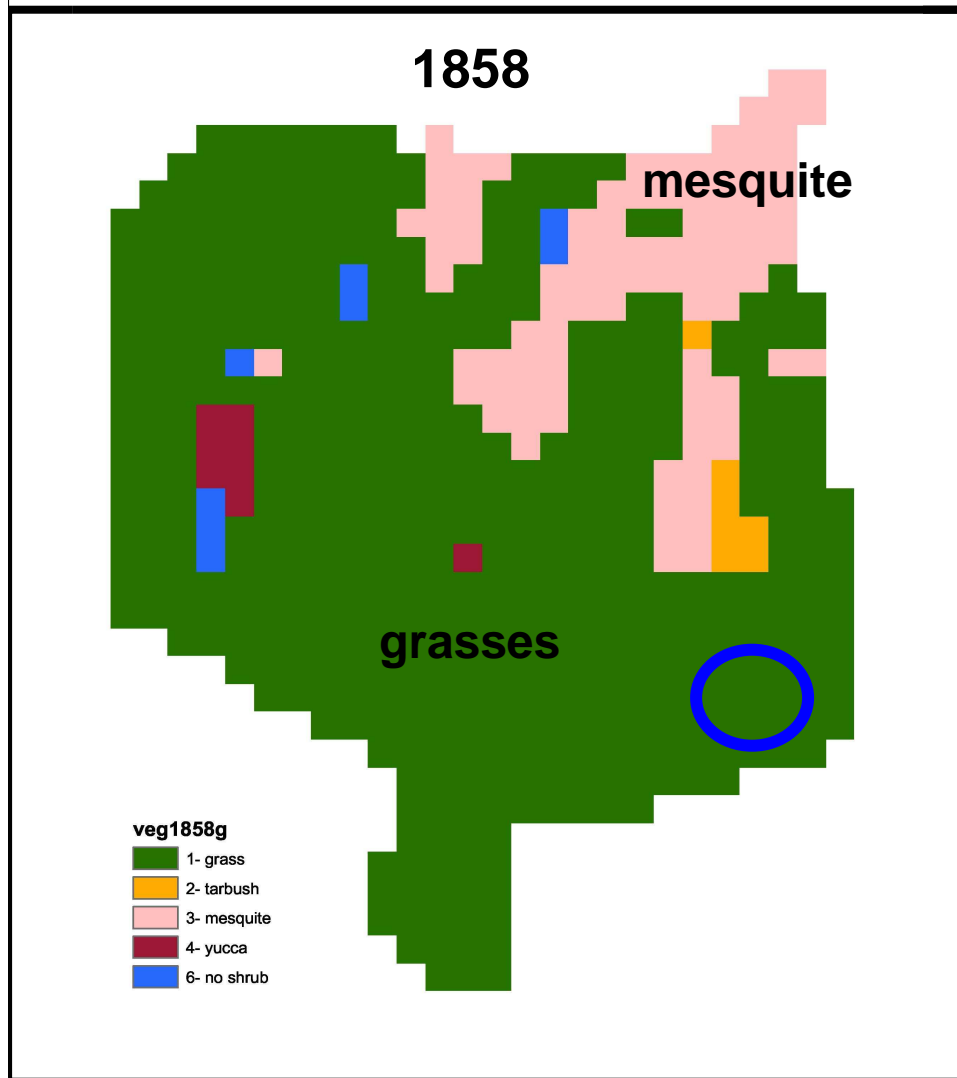
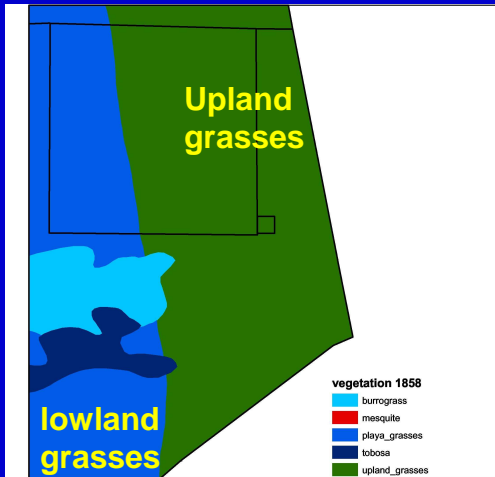(a) Cattle distribution under dry conditions related to plant species distribution

(b) Cattle moved to less palatable species in response to rainfall outside and upslope of the pasture

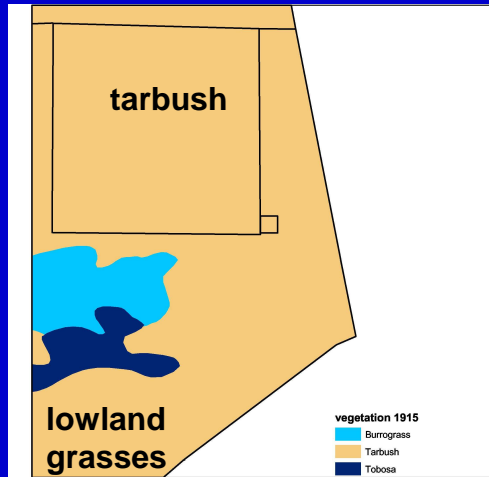# Example: using our framework to explain very slow grass recovery in a shrubland that was dominated by grasslands in 1858

1858

mesquite

grasses

veg1858g
- 1- grass
- 2- tarbush
- 3- mesquite
- 4- yucca
- 6- no shrub

1998

mesquite

creosote

grasses

tarbush

1 sq mile cattle exclosure established in 1938 with adjacent lagomorph exclosure containing shrub removal plots
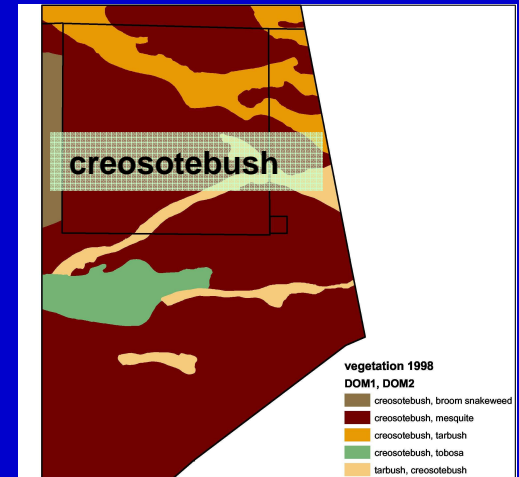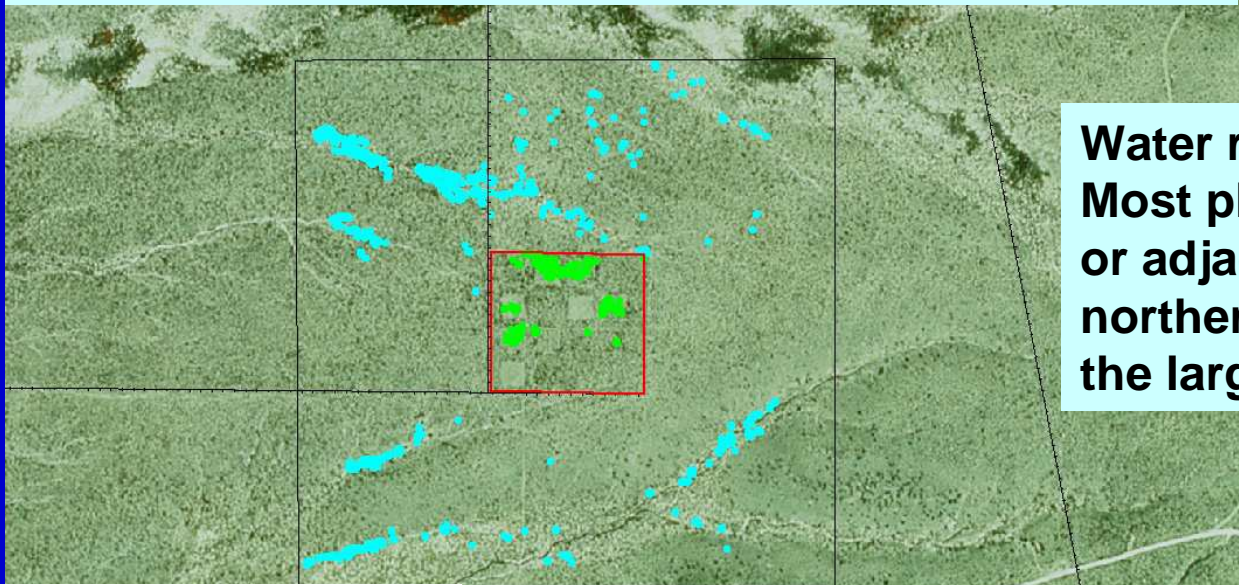
1858 · 1915 · 1998

How can we use this framework to explain very slow recovery of grasses inside the small exclosure?

Spatial context:
Ground survey found 3335 black grama plants in the 29 ha area surrounding the small exclosure (0.01 plants/m^2).

Water redistribution:
Most plants were found inside or adjacent to arroyos at a northern aspect, and outside the large exclosure.

Low seed production

Percentage of black grama plants

Percentage of black grama plant with seedheads
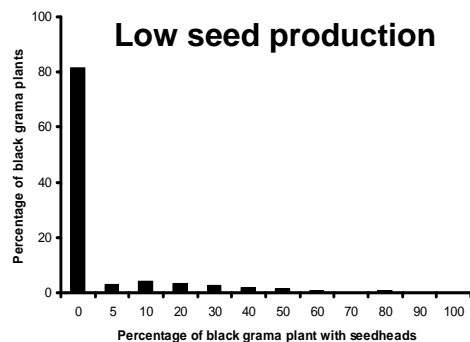
Conclusion:
Recovery limited by viable seeds within dispersal distance for black grama and by microsite conditions within the exclosure

Peters et al. (submitted)

Summary and conclusions

1. High spatial and temporal variability exists in patterns in shrub expansion and grass persistence that can not be explained by grazing and drought.

2. Framework of five system properties that interact across scales can explain this variation.

3. We can use this framework to improve:
    understanding of current patterns
    management under alternative scenarios
    predictions under changing environmental conditions